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Review

Trends and Evolution in the Concept of Marine Ecosystem Services: An Overview

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Abstract: The biotic and abiotic assets of the marine environment form the "marine natural capital" embedded in the global ocean. Marine natural capital provides the flow of "marine ecosystem services" that are directly used or enjoyed by people providing benefits to human well-being. They include provisioning services (e.g., food), regulation and maintenance services (e.g., carbon sequestration and storage, and coastal protection), and cultural services (e.g., tourism and recreational benefits). In recent decades, human activities have increased the pressures on marine ecosystems, often leading to ecosystem degradation and biodiversity loss and, in turn, affecting their ability to provide benefits to humans. Therefore, effective management strategies are crucial to the conservation of healthy and diverse marine ecosystems and to ensuring their long-term generation of goods and services. Biophysical, economic, and sociocultural assessments of marine ecosystem services are much needed to convey the importance of natural resources to managers and policy makers supporting the development and implementation of policies oriented for the sustainable management of marine resources. In addition, the accounting of marine ecosystem service values can be usefully complemented by their mapping to enable the identification of priority areas and management strategies and to facilitate science–policy dialogue. Given this premise, this study aims to review trends and evolution in the concept of marine ecosystem services. In particular, the global scientific literature on marine ecosystem services is explored by focusing on the following main aspects: the definition and classification of marine ecosystem services; their loss due to anthropogenic pressures, alternative assessment, and mapping approaches; and the inclusion of marine ecosystem services into policy and decision-making processes.

Keywords: marine ecosystems; ecosystem services; benefits to humans; biophysical assessment; economic valuation

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1. Introduction

The biotic and abiotic assets of the marine environment constitute natural marine capital generating a bundle of ecosystems services vital for human well-being [1,2].

Marine ecosystem services are the output flows generated by marine natural capital stocks that are directly consumed, used, or enjoyed by people [3–6]. They include food provision, coastal protection, water purification, nutrients cycling, carbon sequestration, and recreational opportunities.

The generation of ecosystem services depends on the physical, chemical, and biological processes in marine ecosystems that underpin ecosystem functioning and maintain ecosystem structures. These ecosystem processes include biomass production, organic matter transformation, nutrient cycling, and physical structuring [7].

Ecosystem functioning is based on the interplay between abiotic and biotic factors. Among the biotic factors, the importance of biodiversity is widely recognized as being fundamental [8]. Furthermore, ecosystem functions represent a significant component of ecosystem health on which the generation of ecosystem services that benefit society and human economy depends [9].

The most widely acknowledged framework for linking ecosystems and human well-being is the ecosystem service cascade model developed to highlight how the notion of ecosystem services can be used to understand the strong relationships between people and nature [10]. It represents the production chain of ecosystem services, starting from the biophysical structures and processes of ecosystems and ending with the benefits provided to society. Yet, the quantitative assessment of the relationships between biodiversity, ecosystem functioning and ecosystem services requires a deep research effort, especially in the context of marine ecosystems [11].

Marine ecosystems undergo unprecedented changes at different scales due to multiple human direct and indirect pressures including overfishing, eutrophication, invasive alien species, habitat destruction, plastic pollution, and climate change [12–14]. Marine biodiversity loss is a consequence of these drivers acting either alone or in synergy. In this context, the biophysical and economic assessment of marine ecosystem services is much needed to convey the importance of natural resources to managers and policy makers and to support the implementation of policies and strategies oriented toward the sustainable exploitation of marine natural capital stocks [15].

Mainstreaming ecosystem services into policy and decision making is also dependent on the availability of spatially explicit information on the state and trends of marine ecosystems. Mapping is recognized as an essential tool to bring the concept of ecosystem services into practical application [16,17].

In recent decades, there has been an increasing number of studies aimed at assessing and mapping the value of coastal and marine ecosystem services, although there are significantly less published articles than for terrestrial ecosystems [18].

In this study, the scientific literature on marine ecosystem services was firstly explored using bibliometric analysis and the VOSviewer software (version 1.6.9, Leiden University, Netherlands), a software tool based on social network analysis allowing for the creation, visualization, and exploration of maps based on bibliometric network data. Articles were collected on 16 February 2021 by research on the Scopus web search engine. The search string used was “marine ecosystem service*”. The research on the Scopus database produced 237 scientific articles published from 2006 to 2021. The results were exported as .csv files and imported into the VOSviewer software. The scientific research on marine ecosystem services has shown a rapid increase in recent decades. The distribution of keywords in scientific publications on “marine ecosystem services” along a temporal gradient (Figure 1) shows the evolution in the scientific literature on the topic, identifying the most recent topics and research paths. The map shows a more recent focus on the concepts of “environmental assessment”, “spatial planning”, and “sustainable development”, highlighting increasing interests and efforts in opening the science on “marine ecosystem services” to multi-disciplinary research areas linking the ecological and socioeconomic dimensions of sustainability.

The concept of ecosystem services has also garnered strong international policy attention. Although there is no specific policy devoted to marine ecosystem services, the concept is already embedded in several recent environmentally related international policies, such as the Marine Strategy Framework Directive, the 2030 Agenda for Sustainable Development, and the Biodiversity Strategy for 2030 [19–21].

Given this premise, this paper aims to review the scientific literature on marine ecosystem services by focusing on the following main aspects: the definition and classification of marine ecosystem services; their loss due to anthropogenic pressures, alternative assessment, and mapping approaches; and the inclusion of marine ecosystem services into policy and decision-making processes.

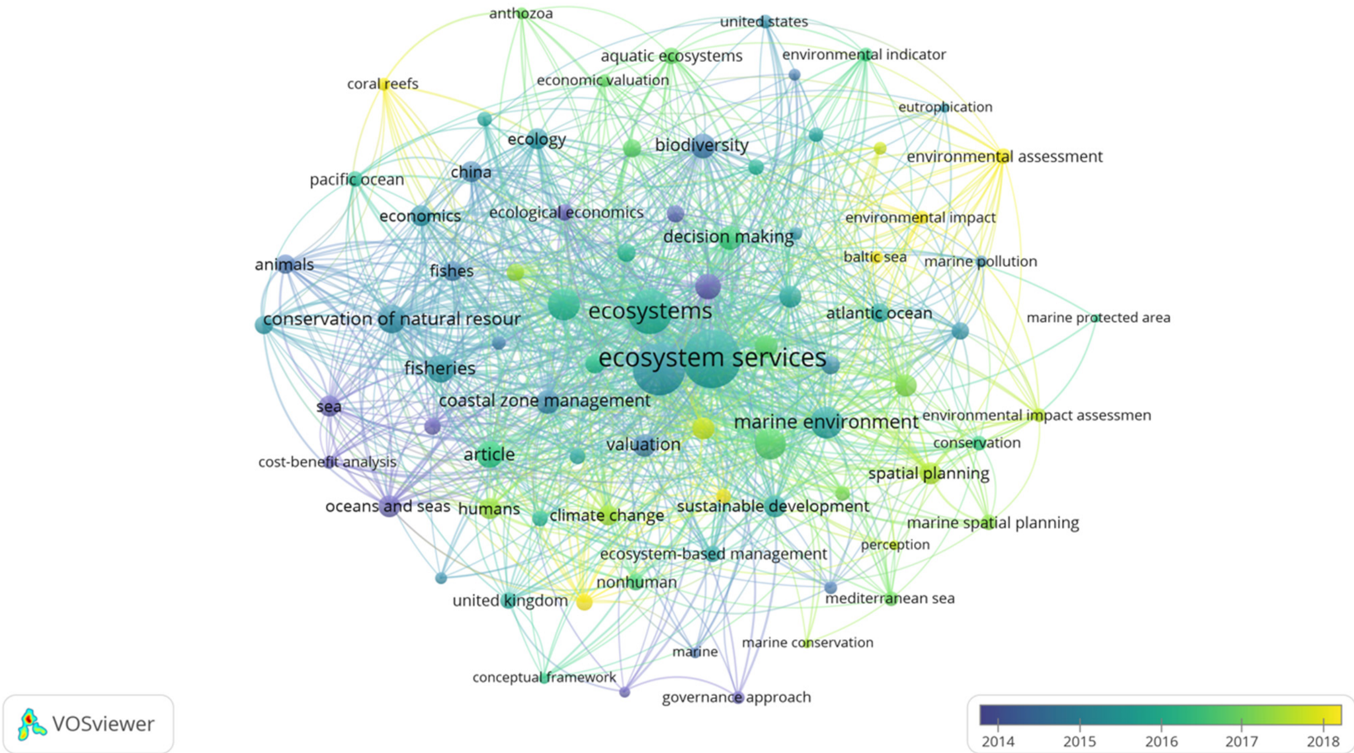

Figure 1. Keywords related to "marine ecosystem services" in the scientific literature, represented on the basis of the average year of publication of documents in which they occur, on a color gradient from blue (older publications) to green (publications equally distributed across the timespan) and yellow (more recent publications).

2. Definition and Classification of Marine Ecosystem Services

In recent decades, there has been an exponential growth in interest on the ecosystem service concept and on related international initiatives, among which include the Millennium Ecosystem Assessment (MA), The Economics of Ecosystem Services and Biodiversity (TEEB), the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES), and the Common International Classification of Ecosystem Services (CICES). These policy-relevant initiatives provided several definitions and classification schemes for ecosystem services.

The MA [22] defined marine ecosystem services as "benefits that people obtain from coastal and marine ecosystems" and divided coastal and marine ecosystem services into four main categories: Provisioning Services such as food, water, timber, and fiber; Regulating Services such as the regulation of climate, floods, disease, wastes, and water quality; Cultural Services such as recreational, aesthetic, and spiritual benefits; and Supporting Services such as soil formation, photosynthesis, and nutrient cycling. The MA considered fishery catches as one of the most important services derived from coastal and marine ecosystems both in terms of source of proteins and direct and indirect employment opportunities to millions of people worldwide [23]. In the MA context, a special focus was placed on the major anthropogenic drivers of change, degradation, or loss of marine and coastal ecosystems and services.

Following the MA, ecosystem services were defined in TEEB [24] as "the direct and indirect contributions of ecosystems to human well-being". This definition followed the MA, but it introduced a distinction between the concepts of "services" (i.e., flows generated by natural ecosystems) and "benefits" (i.e., the contributions of ecosystem service flows to aspects of human well-being such as health and safety), explicitly acknowledging that services can benefit people in multiple and indirect ways.

Another important difference, compared with the MA, was the omission of the Supporting Services, which were considered in the TEEB as a subset of ecological processes.

Instead, the Habitat Services category was introduced as a separate category to highlight the importance of ecosystems in providing habitat for migratory species and gene-pool protectors. The TEEB initiative recognized that, although the ocean and coastal ecosystems are extremely important in terms of ecosystem services they provide and their economic value, they suffer from knowledge and governance deficits more than other types of ecosystems [24]. In the TEEB context, major attention was placed on the need for assessing the economic value of marine and coastal ecosystems while understanding the contribution of these ecosystems to human well-being.

The Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) introduced the concept of "nature's benefits to people", referring to all of the benefits that humanity (individuals, communities, societies, nations, or humanity as a whole) obtains from nature [25]. Later, the IPBES introduced the concept of "nature's contribution to people", with the goal of embracing different stakeholders; world views; the knowledge base offered by the natural and social sciences; and the knowledge of practitioners, indigenous, and local communities [26]. With regard to the contribution provided to humans by marine ecosystems, the IPBES highlighted the need for ecosystem-based approaches to fisheries management, marine spatial planning, marine protected areas, and other tools to protect and manage key marine biodiversity areas. In particular, fishing was recognized as the human activity with the highest impact on biodiversity in the past 50 years. Therefore, it is suggested to urgently enhance capacity-building for the adoption of sustainable fisheries management practices; to implement global agreements for responsible fisheries; and to prevent and eliminate illegal, unreported, and unregulated fishing [26].

Currently, the most widely used classification of ecosystem services is the Common International Classification of Ecosystem Services (CICES). The first version of the CICES was published in 2013 and, then, updated in 2018 to clarify the way specific ecosystem services are defined and to extend the scope of the classification [5]. Both the first and the second versions of the CICES define ecosystem services as "the contributions that ecosystems make to human well-being". The CICES clustered ecosystem services in three main categories (provisioning, regulating and maintenance, and cultural). The "supporting services" category, originally defined in the MA, was excluded in the CICES since it was treated as part of the structures, processes, and functions of ecosystems. The CICES was first developed for terrestrial environments, but it has since been adapted for the marine environment [27]. According to the CICES classification, marine ecosystem services can be also divided into three main categories [28]. The provisioning category includes food provision (i.e., through fishing activities and aquaculture), water storage and provision (i.e., water extraction in marine and coastal environments), and biotic materials and biofuels (i.e., medicinal, ornamental and other commercial resources, and biomass for bioenergy). The regulating and maintenance category embeds water purification, air-quality regulation by vegetation and water bodies, coastal protection, climate regulation (i.e., regulation of greenhouse and climate active gases), weather regulation, ocean nourishment through nutrients cycling, life cycle maintenance (i.e., the maintenance of key habitats that act as nurseries, spawning areas, or migratory routes), and biological regulation (e.g., control of fish pathogens especially in aquaculture and the role of cleaner fishes in coral reefs). Finally, cultural services include symbolic and aesthetic values, recreation and tourism (e.g., coastal and offshore activities), and cognitive effects (e.g., inspiration for arts and applications, information, and awareness).

3. Loss of Marine Ecosystem Services

Coastal and marine ecosystems represent some of the most heavily exploited ecosystems in the world [1]. The loss of marine biodiversity is increasingly harming the capacity of marine ecosystems to provide services to humans, and the trend of biodiversity loss is accelerating on a global scale [29]. About 60% of global marine ecosystems have been degraded or unsustainably used [30]. Coastal habitats are under pressure, with approximately 20% of the world's coral reefs lost and about 20% degraded. Mangroves have been reduced by 30–50% compared with their historical cover, and about 29% of seagrass habitats are estimated to have disappeared in the last century, generating loss of biodiversity, habitats for inshore fisheries, and carbon sequestration potential [31]. There are several anthropogenic drivers of change, degradation, and loss of marine and coastal ecosystems that can be divided into the categories direct and indirect [23]. A direct driver unequivocally affects ecosystem processes, while an indirect driver operates more diffusely by altering one or more direct drivers. According to MA [22], driving forces can be clustered in the following categories: demographic, economic, sociopolitical, cultural and religious, science and technology, and physical and biological. Drivers in the category "physical and biological" can be considered direct [22], while drivers belonging to the other categories can be considered indirect. Direct drivers of change in marine and coastal ecosystems include overfishing and destructive fishing methods, invasive species, pollution and nutrient loading (eutrophication), and climate change. In contrast, illegal fishing, and population growth are among the major indirect drivers of change in marine and coastal ecosystems.

Overfishing and destructive fishing methods alter or destroy marine ecosystems, and change the community structure and the interactions between ecosystem components. The global decline in commercially important fish stocks is well documented, with many important ecological, economic, and social consequences. In fact, according to FAO [32], the fraction of fish stocks that are within biologically sustainable levels has exhibited a decreasing trend from 90% in 1974 to 67% in 2015. Conversely, the percentage of stocks fished at biologically unsustainable levels increased from 10% in 1974 to 33% in 2015.

Marine invasive species are a growing global ecological threat [33]. The introduction of alien marine species has been accelerated in recent decades by rapid globalization and increasing trends in trade, travel and transport, and climate change [34]. The introduction of marine alien species can generate significant ecological, economic, and human health impacts [35]. From an ecological perspective, they can cause loss of native biodiversity (due to preying upon native species, decreased habitat availability for native species, and additional competition), changes to ecosystem function and in nutrient cycles, and decreases in water quality.

In terms of economic impacts, marine invasive species can interfere with fishing and mariculture activities, damage infrastructure, and disturb tourism. Finally, they can increase the presence of parasites and diseases, decrease recreational opportunities, and degrade culturally important habitats and resources.

Marine pollution is also a complex threat to marine biodiversity. Many human activities generate pollutants that are released into the seas and the oceans. These pollutants can significantly alter marine ecosystems and cause serious harm to species of the marine food web [36].

Pollutants often originate from land and are transported to the oceans through rivers or the air. Pollutants of particular concern include petroleum, nutrients from fertilizers, industrial contaminants, and plastics. In particular, in the last decade, the global problem of plastic pollution in the seas and oceans has attracted increasing scientific concern, with calls for international agreements to address this issue [37,38]. Annually, an estimated 211,425 tons of plastic enter the marine environment [39]. A timely debate addresses the presence and concentration of microplastics in fishes, a critical topic considering that, globally, more than 40 million people are dependent on fish provisioning [40]. In addition, although there has been an increasing interest towards the issue of microplastics in marine environments, there remains a lack of understanding of how they can affect the biodiversity and the functioning of marine ecosystems and, indirectly, the generation of ecosystem services [41].

Climate change is another serious threat to marine ecosystems. The ocean absorbs large amounts of heat as a result of increased concentrations of heat-trapping gases in the atmosphere, leading to rising ocean temperatures [42]. Ocean warming leads to a reduction in the amount of dissolved oxygen and sea-level rise resulting from the thermal expansion of sea water and continental ice melting. Increasing ocean temperatures, coupled with ocean acidification (i.e., the decrease in pH of the ocean due to the uptake of CO_2) affect marine species and ecosystems. Rising temperatures cause coral bleaching and the loss of breeding grounds for marine fishes and mammals [43,44]. Several studies indicate that the impacts of anthropogenic climate change include decreased ocean productivity, altered food web dynamics, reduced abundance of habitat-forming species, shifting species distributions, and a greater incidence of disease [45]. Although there is considerable uncertainty about the spatial and temporal details, climate change is clearly and fundamentally altering ocean ecosystems [46,47]. The impacts of climate change are increasing in intensity and are predicted to have great effects on marine resources and ecosystems in the future, also creating serious challenges for societies worldwide, especially in developing countries.

Among indirect drivers of change in marine and coastal ecosystems, illegal fishing practices, aimed at achieving high economic profits and due to a lack of surveillance, enforcement, and monitoring, also contribute to the overexploitation of fish stocks [23].

Moreover, demographic development in coastal zones is also an indirect driver of changes in ecosystems, with coastal population densities being about three times that of inland areas, thus affecting many of the most ecologically important and valuable ecosystems within the coastal zones [23].

The cumulative anthropogenic pressures on marine ecosystems cause biodiversity loss and seriously affect their capacity to provide benefits to humans [48,49]. Anthropogenic impacts on marine ecosystems are a growing concern especially in coastal areas where several human activities occur, generating large inflows of pollutants and hazardous wastes [50]. In fact, although the coastal zones represent only about 4% of the Earth's total land area, they contain more than one third of the world's population and account for about 90% of the catches from marine fisheries [1].

The degradation of marine ecosystems, the loss of biodiversity, and related ecosystem services call for placing a value on nature. In fact, comprehensive assessment framework providing biophysical and socioeconomic evaluations of marine ecosystems and related services are strongly needed to communicate with policy and decision-makers and to implement conservation actions and sustainable management of marine ecosystems.

Therefore, in view of the current human pressures causing marine biodiversity loss, effective management strategies are crucial to conserving healthy and diverse marine ecosystems; to maintaining the valuable functions and services they provide, and at the same time; to practicing sustainable socioeconomic activities.

4. Assessing and Mapping Marine Ecosystem Services

Assessing and mapping ecosystems and their services are essential to making informed decisions [51]. Ecosystem service assessment is a worldwide topic garnering growing interest, but applications for coastal and marine ecosystems are still a minority [52]. The assessment of ecosystem services in marine ecosystems is more challenging compared to terrestrial ones [53]. In fact, the dynamics and complexity of marine ecosystems, the high connectivity among marine habitats, the dispersal of species, and the widespread spatial distribution of the ecological processes make the assessment of ecosystem services demanding and time- and resource-consuming [54].

In spite of this, over the past decades, there has been increasing research effort in assessing the value of services generated by marine ecosystems and in incorporating these values into marine planning and decision making [18].

Marine ecosystem service assessment can be performed by using biophysical, sociocultural, and economic methods [55]. These methods are complementary to each other and can provide different sets of indicators in support of decision makers.

Biophysical assessment methods are based on the quantification of different parameters of biotic and abiotic structures on which the provision of ecosystem services depends. Biophysical methods can be divided into three main categories: direct measurement, indirect measurement, and modelling methods [56].

Direct measurement methods assess the quantity and the state of marine ecosystem services from ecosystem observations, monitoring, surveys, and questionnaires. Marine habitat mapping represents the basis for direct ecosystem service assessment, and several efforts have been made within the habitat mapping community for supporting ecosystem service assessment [57–59]. Direct measurements provide a biophysical value of ecosystem services in physical units (e.g., kg per year), which correspond to the units of the indicator and usually quantify both the stock and the flow values [60].

Indirect measurement methods are based on the use of different data sources that rely on biophysical values (expressed in physical units) and still need additional analysis, interpretation, assumptions, and data processing. They can be based for instance on remote sensing, Earth observations, and other datasets that are further processed through specific procedures [61].

Modelling methods are based on the implementation of models for assessing ecosystem services and includes approaches from different disciplines, among which include ecology, statistics, and climatology. Ecological models, for instance, have been used for assessing marine primary production, which plays a crucial role as an energy source for structuring marine food webs on which, in turn, the generation of ecosystem services depends [62–64]. Conceptual models and integrated modelling frameworks are also included in this category. Integrated modelling frameworks are also used for sociocultural and economic methods.

Marine ecosystem services can be also assessed in monetary units by calculating the total economic values (TEVs), which include the direct, indirect, and non-use contributions of marine ecosystems to humanity [3].

Monetary valuations can be used within frameworks that evaluates both conventional economic activity and changes in natural ecosystems within a unified accounting system [65]. In addition, the monetary valuation of ecosystem services can be used to embed the impacts of policies or management actions affecting marine ecosystems in benefit–cost analyses. On the other hand, economic evaluations may not be capable of capturing the full range of ecological, sociocultural, and non-anthropocentric values that can be associated to marine ecosystems.

Along with biophysical and economic values, sociocultural methods are also used to emphasize the value of goods and services that ecosystems provide to social well-being [66].

Sociocultural values depict the principles, importance, or preferences expressed by people towards nature [25,67] and can be instrumentally, intrinsically, and relationally motivated [68]. Sociocultural methods aim to expand ecosystem service assessments by explicitly incorporating cultural and social metrics into the analysis [69].

The "System of Environmental-Economic Accounting 2012-SEEA Central Framework" was adopted by the United Nations Statistical Commission in 2012 as an international standard for performing environmental-economic accounting. It focuses on the stocks of natural resources and the flows exchanged between the economy and the environment and provides an accounting framework that can be integrated within the System of National Accounts.

The SEEA Experimental Ecosystem Accounting was then published in 2014. It offers a synthesis of the current knowledge on ecosystem accounting and provides a standardized set of terms, concepts, and accounting principles and an integrated accounting structure for ecosystem services in both physical and monetary terms. It also includes a chapter on the main challenges and methodological options for the monetary valuation of ecosystems and ecosystem services. While the SEEA framework has been widely applied to terrestrial ecosystems, there are only few studies on coastal and marine ecosystems [70]. Of note is the European Commission's Knowledge Innovation Project for an Integrated System for Natural Capital and Ecosystem Services Accounting (KIP INCA), which aimed at developing a marine ecosystem accounting framework for seagrass [71].

With regard to the assessment of marine ecosystem services at the global scale, Costanza et al. [72] provided an estimate of 20.9 trillion USD per year, representing more than 60% of the total value of global ecosystem services. de Groot et al. [73] also estimated the value of ecosystem services in monetary units for 10 main biomes, including open oceans, coastal systems, and coral reefs, based on local case studies across the world. Later, Costanza et al. [74] provided an updated estimate of ecosystem services at the global scale based on updated datasets. In this study, the updated value calculated for global marine ecosystem services resulted in 49.7 trillion USD per year.

Several researchers have highlighted the limitations of global ecosystem service valuation. One of the main problems is related to the limited availability of data to conduct benefit transfers at the global scale. In fact, Pendleton et al. [75] conducted a literature review on the valuation of coastal and marine ecosystem services, highlighting that studies were mainly only concentrated on four coastal and marine ecosystems (i.e., coastal beaches, marine fishing, coastal lands, and wetlands) and that the geographic coverage was concentrated in a few states [18]. Although there are several limitations of global scale assessments of ecosystem services, they have been important in raising awareness on the importance of ecosystems for human well-being. Nonetheless, the limitations of the results produced by global assessments highlight the lack of accurate and comprehensive global data for ecosystem service assessment, especially for marine and coastal areas [75].

Numerous studies aimed at assessing marine ecosystem services at the local scale based on site-specific data. For example, among recent studies, Depellegrin et al. [76] assessed marine ecosystem service richness and exposure to anthropogenic threats in small sea areas of the Lithuanian sea; Outeiro et al. [77] performed a spatial-economic analysis and a social assessment to understand the tradeoffs between different marine ecosystem services in a Brazilian marine protected area; and Manea et al. [54] mapped and assessed supporting ecosystem services in the Adriatic Sea (Italy).

Still, there is a lack of comprehensive assessment performed at the national and regional scales because spatial data are often lacking for large marine ecosystems or regional seas. Assessments of ecosystem services at larger scales are crucial for environmental policies, such as the EU Marine Strategy Framework Directive (MSFD, EC, 2008) requiring marine assessments and management efforts at the level of European regional seas [27].

In addition to assessments, ecosystem service mapping is recognized as a critical instrument in bringing ecosystem services into practical applications [78].

Many ecosystem services face spatially explicit pressures, and their exploitation is often based on anthropogenic activities. Ecosystem service maps can help identify where to improve the provision of ecosystem services and where to prioritize nature and biodiversity conservation [79].

The availability of spatial information on the state and trends of ecosystems and their services is essential for mainstreaming ecosystem services into policy and decision making [16].

Mapping ecosystem services is also used to quantify the capacity of ecosystems to deliver services, i.e., ecosystem service supply, and the amount of used goods and services for human benefits, i.e., ecosystem service demand [80]. Mapping ecosystem service supply and demand is useful in increasing policy relevance and practical in including the concept of ecosystem services in operational management [81,82].

Marine ecosystem service mapping has been mainly focused on regulating services, especially carbon sequestration and storage [28], and provisioning services, mainly through fisheries and aquaculture activities [83,84]. In contrast, cultural services and education or recreational opportunities are among the least mapped ecosystem services in coastal and marine environments [85].

Although the importance of marine ecosystem service mapping in marine planning is highly recognized, the mapping of coastal and marine ecosystem services remains limited compared to terrestrial ecosystems [17]. In fact, mapping marine ecosystem services has many challenges. First, it is very difficult to gather enough qualitative and quantitative information to describe all of the dimensions and the complexity of marine ecosystems [78]. In the oceans and coastal areas, many ecosystem processes occur in the water column, adding a third spatial dimension to the system. Ecosystem dynamics change with depth, water temperature, solar irradiance, salinity, and other factors, and it is very difficult to capture this information in two-dimensional maps.

It is also hard to represent the benthic and pelagic dynamics across time, to define the boundaries of marine ecosystems, and to associate species with their marine habitats at a good spatial scale [86]. While marine habitat maps represent an invaluable basis for ecosystem service assessment, maps of the same area built using different methods and parameters may lead to dissimilar representations, thus providing different information [59]. Therefore, uncertainty in marine habitat mapping should be reported and taken into account to effectively support decision-makers in developing conservation and management plans. In addition, there is a challenge related to the availability of uncertain existing maps that could prevent their use. Finally, while several studies have performed marine ecosystem mapping at the regional or national scales, there is still a need for mapping based on global environmental datasets [87].

5. Including Marine Ecosystem Services in Policy and Decision-Making Processes

Despite the integration of marine ecosystems and their services in policy and decision-making still being challenging, the concept is becoming integrated into several international regulations and policies.

The EU Marine Strategy Framework Directive (MSFD, 2008/56/EC) aims for good environmental status in marine waters, following an ecosystem-based approach. It is focused on 11 descriptors related to ecosystem features, human drivers, and pressures for determining good environmental status. However, within the existing descriptors, only ecosystem services are indirectly included. For example, the descriptor "Commercially exploited fish and shellfish" defines criteria to ensure sustainable fishing and catches, indirectly referring to the ecosystem service of food provision [88].

The concept of ecosystem services is explicitly integrated into the European Commission EU Biodiversity Strategy to 2020 as a way of mainstreaming biodiversity into other policies. The EU Biodiversity Strategy to 2020 is built on six mutually supportive and inter-dependent targets that address the main drivers of biodiversity loss and aims at reducing key pressures on nature and ecosystem services in the EU. Global aspects are also addressed to ensure that the EU fully contributes to implementing international biodiversity commitments [89]. In particular, the second target focuses on maintaining and enhancing marine and terrestrial ecosystem services and on restoring degraded ecosystems.

In recent years, several efforts have been made to operationalize the Maritime Spatial Planning Directive (MSPD, 2014/89/EU). Maritime spatial planning has been introduced as an instrument to provide support in achieving integrated maritime governance, ensuring sustainable development, Blue Growth, and good marine environmental status. The concept of marine ecosystem services is central to the MSPD. In fact, the MSPD aims to manage maritime activities to avoid conflicts among them and with marine ecosystems, while allows for the sustainable exploitation of marine resources and marine ecosystem services.

The concept of marine ecosystem services is also central in the ongoing UN Decade of Ocean Science for Sustainable Development. In fact, several programs and contributions have been endorsed as the first set of Decade Actions, such as the Blue Climate Initiative and the Cultural Heritage Framework Programme, recognizing that the research on marine ecosystem services plays a crucial role in generating scientific knowledge needed to fully contribute to global ocean sustainability and human well-being.

Therefore, national governments, international organizations, businesses, and non-governmental organizations have started incorporating ecosystem services into policy and management, but still, additional efforts are needed for successful implementation, making the concept of ecosystem services operational and linked with decision-making, especially in the case of marine ecosystems [90].

Future efforts should be aimed at developing solid evidence linking decisions to the anthropogenic impacts on ecosystems and generated services and, as a consequence, to human well-being; working with leaders in governments, businesses, and civil society to develop and provide knowledge and tools to effectively integrate ecosystem services into decision-making processes; and reforming policies and institutions, and building capacities to better align with private, short-term goals and with societal, long-term goals [91].

6. Conclusions

In recent decades, the scientific literature on marine ecosystem services has rapidly increased while, in parallel, the concept has become integrated into several international regulations and policies.

Several methodologies have been used to quantify the benefits that humans receive from marine ecosystems. All of these methods are complementary to each other and can provide different indicators that can support policy makers in deciding and choosing among alternative investments, projects, and policies. The choice of an assessment method largely depends on the type of problem investigated, the peculiarity of the study area, and the final goal of the assessment.

An integration of biophysical, economic, and sociocultural assessment methods is desirable for a broader and comprehensive understanding of the benefits gained from marine ecosystems and the ecological, social, and economic costs due to their unsustainable exploitation.

Efforts are still needed to advance the research on marine ecosystem services at the local, national, regional, and global scales and to provide policy makers with useful indicators to implement effective strategies for the sustainable use and management of coastal and marine ecosystems.

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References

1. Barbier, E.B. Marine ecosystem services. *Curr. Biol.* **2017**, *27*, R507–R510. [CrossRef] [PubMed]
2. Buonocore, E.; Donnarumma, L.; Appolloni, L.; Miccio, A.; Russo, G.F.; Franzese, P.P. Marine natural capital and ecosystem services: An environmental accounting model. *Ecol. Model.* **2020**, *424*, 109029. [CrossRef]
3. Fisher, B.; Turner, K.; Zylstra, M.; Brouwer, R.; De Groot, R.; Farber, S.; Ferraro, P.; Green, R.; Hadley, D.; Harlow, J.; et al. Ecosystem services and economic theory: Integration for policy-relevant research. *Ecol. Appl.* **2008**, *18*, 2050–2067. [CrossRef] [PubMed]
4. Häyhä, T.; Franzese, P.P. Ecosystem services assessment: A review under an ecological-economic and systems perspective. *Ecol. Model.* **2014**, *289*, 124–132. [CrossRef]
5. Haines-Young, R.H.; Potschin, M.B. *Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure*; Fabis Consulting Ltd.: Barton, UK, 2018.
6. Maes, J.; Teller, A.; Erhard, M.; Liquete, C.; Braat, L.; Berry, P.M.; Egoh, B.; Puydarrieux, P.; Fiorina, C.; Santos, F.; et al. *Mapping and Assessment of Ecosystems and their Services. An Analytical Framework for Ecosystem Assessments Under Action 5 of the EU Biodiversity Strategy to 2020*; Publications Office of the European Union: Luxembourg, 2013.
7. Strong, J.A.; Andonegi, E.; Bizsel, K.C.; Danovaro, R.; Elliott, M.; Franco, A.; Garces, E.; Little, S.; Mazik, K.; Moncheva, S.; et al. Marine biodiversity and ecosystem function relationships: The potential for practical monitoring applications. *Estuar. Coast. Shelf Sci.* **2015**, *161*, 46–64. [CrossRef]
8. Daam, M.A.; Teixeira, H.; Ana, I.; Lillebø, A.; Nogueira, J.A. Establishing causal links between aquatic biodiversity and ecosystem functioning: Status and research needs. *Sci. Total. Environ.* **2019**, *656*, 1145–1156. [CrossRef] [PubMed]

9. Paterson, D.; Defew, E.; Jabour, J. Ecosystem Function and co-evolution of terminology in marine science and management. *Mar. Biodivers. Ecosyst. Funct.* **2012**, *1*, 1–240.
10. Potschin-Young, M.; Haines-Young, R.; Gorg, C.; Heink, U.; Jax, K.; Schleyer, C. Understanding the role of conceptual frameworks: Reading the ecosystem service cascade. *Ecosyst. Serv.* **2018**, *29*, 428–440. [CrossRef]
11. Galparsoro, I.; Angel, B.; Uyarra, M.C. Mapping ecosystem services provided by benthic habitats in the European North Atlantic Ocean. *Front. Mar. Sci.* **2014**, *1*, 23. [CrossRef]
12. Ani, C.J.; Robson, B. Responses of marine ecosystems to climate change impacts and their treatment in biogeochemical ecosystem models. *Mar. Pollut. Bull.* **2021**, *166*, 112223. [CrossRef] [PubMed]
13. Küpper, F.C.; Kamenos, N.A. The future of marine biodiversity and marine ecosystem functioning in UK coastal and territorial waters (including UK Overseas Territories)—with an emphasis on marine macrophyte communities. *Bot. Mar.* **2018**, *61*, 521–535. [CrossRef]
14. Worm, B.; Barbier, E.B.; Beaumont, N.; Duffy, J.E.; Folke, C.; Halpern, B.S.; Jackson, J.B.C.; Lotze, H.K.; Micheli, F.; Palumbi, S.R.; et al. Impacts of biodiversity loss on ocean ecosystem services. *Science* **2006**, *314*, 787–790. [CrossRef] [PubMed]
15. Buonocore, E.; Buia, M.C.; Russo, G.F.; Franzese, P.P. Exploring the convergence of natural flows for the generation of natural capital stocks in marine ecosystems. *Ecol. Complex.* **2021**, *46*, 100928. [CrossRef]
16. Maes, J.; Egoh, B.; Willemen, L.; Liquete, C.; Vihervaara, P.; Schagner, J.P.; Grizzetti, B.; Drakoua, E.G.; Alessandra LaNotte, A.; Zulian, G.; et al. Mapping ecosystem services for policy support and decision making in the European Union. *Ecosyst. Serv.* **2012**, *1*, 31–39. [CrossRef]
17. Nahuelhual, L.; Vergara, X.; Kusch, A.; Campos, G.; Droguett, D. Mapping ecosystem services for marine spatial planning: Recreation opportunities in Sub-Antarctic Chile. *Mar. Policy* **2017**, *81*, 211–218. [CrossRef]
18. Milon, J.; Alvarez, S. Coastal Resources Economics and Ecosystem Valuation. *Water* **2019**, *11*, 2206. [CrossRef]
19. Bouwma, I.; Schleyer, C.; Primmer, E.; Winkler, K.J.; Berry, P.; Young, J.; Carmen, E.; Špulerová, J.; Bezák, P.; Preda, E.; et al. Adoption of the ecosystem services concept in EU policies. *Ecosyst. Serv.* **2018**, *29*, 213–222. [CrossRef]
20. European Commission. EU Biodiversity Strategy for 2030 Bringing Nature Back into Our Lives. 2020. Available online: https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en (accessed on 28 July 2021).
21. United Nations. Transforming our World: The 2030 Agenda for Sustainable Development. 2015. Available online: https://sdgs.un.org/2030agenda (accessed on 28 July 2021).
22. Duraiappah, A.K.; Naeem, S.; Agardy, T.; Ash, N.J.; Cooper, H.D.; Diaz, S.; Faith, D.P.; Mace, G.; McNeely, J.A.; Mooney, H.A.; et al. *Ecosystems and Human Well-Being: Biodiversity Synthesis. Millennium Ecosystem Assessment*; World Resources Institute: Washington, DC, USA, 2005.
23. UNEP. *Marine and Coastal Ecosystems and Human Wellbeing: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment*; UNEP: Washington, DC, USA, 2006; p. 76.
24. TEEB. *Why Value the Oceans—A Discussion Paper*; The Economics of Ecosystems and Biodiversity (TEEB): Geneva, Switzerland, 2012.
25. Díaz, S.; Demissew, S.; Carabias, J.; Joly, C.; Lonsdale, M.; Ash, N. The IPBES conceptual framework—connecting nature and people. *Curr. Opin. Environ. Sustain.* **2015**, *14*, 1–16. [CrossRef]
26. Díaz, S.M.; Settele, J.; Brondízio, E.; Ngo, H.; Guèze, M.; Agard, J.; Arneth, A.; Balvanera, P.; Brauman, K.; Butchart, S. *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*; IPBES: Bonn, Germany, 2019; p. 56.
27. Culhane, F.E.; Frid, C.L.J.; Gelabert, E.R.; Piet, G.; White, L.; Robinson, L.A. Assessing the capacity of European regional seas to supply ecosystem services using marine status assessments. *Ocean. Coast. Manag.* **2020**, *190*, 105154. [CrossRef]
28. Liquete, C.; Piroddi, C.; Drakou, E.G.; Gurney, L.; Katsanevakis, S.; Charef, A.; Egoh, B. Current Status and Future Prospects for the Assessment of Marine and Coastal Ecosystem Services: A Systematic Review. *PLoS ONE* **2013**, *8*, e67737. [CrossRef]
29. Johnson, C.N.; Balmford, A.; Brook, B.W.; Buettel, J.C.; Galetti, M.; Guangchun, L.; Whilmshurst, J.M. Biodiversity losses and conservation responses in the Anthropocene. *Science* **2017**, *356*, 270–275. [CrossRef] [PubMed]
30. UNEP. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication (a Synthesis for Policy Makers); United Nations Environment Programme: 2011. Available online: https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=126&menu=35 (accessed on 28 July 2021).
31. Bradly, N.; Moorhouse, C. *A Blueprint for Ocean and Coastal Sustainability*; IOC/UNESCO: Paris, France, 2011; p. 42.
32. Sofia, F. *The State of World Fisheries and Aquaculture 2018-Meeting the Sustainable Development Goals*; Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations: Rome, Italy, 2018.
33. Anton, A.; Geraldi, N.R.; Lovelock, C.E.; Apostolaki, E.T.; Bennett, S.; Cebrian, J.; Krause-Jensen, D.; Marbà, N.; Martinetto, P.; Pandolfi, J.M.; et al. Global ecological impacts of marine exotic species. *Nat. Ecol. Evol.* **2019**, *3*, 787–800. [CrossRef] [PubMed]
34. Katsanevakis, S.; Tempera, F.; Teixeira, H. Mapping the impact of alien species on marine ecosystems: The Mediterranean Sea case study. *Divers. Distrib.* **2016**, *22*, 694–707. [CrossRef]
35. De Poorter, M.; Darby, C.; MacKay, J. Marine Menace: Alien Invasive Species in The Marine Environment; IUCN Publication: 2009. Available online: https://www.cbd.int/invasive/doc/marine-menace-iucn-en.pdf (accessed on 28 July 2021).
36. NAS—National Academy of Sciences. Pollution in the Ocean. Highlights of National Academies Reports. 2007. Available online: https://www.nap.edu/resource/13353/pollution.pdf (accessed on 28 July 2021).

37. Haward, M. Plastic pollution of the world's seas and oceans as a contemporary challenge in ocean governance. *Nat. Commun.* **2018**, *9*, 667. [CrossRef] [PubMed]
38. Pauna, V.H.; Buonocore, E.; Renzi, M.; Russo, G.F.; Franzese, P.P. The issue of microplastics in marine ecosystems: A bibliometric network analysis. *Mar. Pollut. Bull.* **2019**, *149*, 110612. [CrossRef]
39. BLUEMED Pilot: For a Plastic-Free, Healthy Mediterranean Sea. Summary Report. 2019. Available online: http://www.bluemed-initiative.eu/wp-content/uploads/2019/11/Draft-Report-Towards-a-BLUEMED-Pilot-Plastic-free-Med-V25032019.pdf (accessed on 28 July 2021).
40. Rainieri, S.; Barranco, A. Microplastics, a food safety issue? *Trends Food Sci. Technol.* **2019**, *84*, 55–57. [CrossRef]
41. D'Alessandro, M.; Esposito, V.; Porporato, E.M.D.; Berto, D.; Renzi, M.; Giacobbe, S.; Scotti, G.; Consoli, P.; Valastro, G.; Andaloro, F.; et al. Relationships between plastic litter and chemical pollutants on benthic biodiversity. *Environ. Pollut.* **2018**, *242*, 1546–1556. [CrossRef] [PubMed]
42. Cheng, L.; Abraham, J.; Hausfather, Z.; Trenberth, K.E. How fast are the oceans warming? *Science* **2019**, *363*, 128–129. [CrossRef]
43. Wilkinson, G.R.; Wilkinson, C.R.; Buddemeier, R.W. *Global Climate Change and Coral Reefs: Implications for People and Reefs. Report of the UNEP-IOC-ASPEI-IUCN Global Task Team on the Implications of Climate Change on Coral Reefs*; IUCN: Gland, Switzerland, 1994.
44. Obura, D.O.; Grimsdith, G. *Resilience Assessment of Coral Reefs—Assessment Protocol for Coral Reefs, Focusing on Coral Bleaching and Thermal Stress*; IUCN working group on Climate Change and Coral Reefs; IUCN: Gland, Switzerland, 2009; p. 70.
45. Hoegh-Guldberg, O.; Bruno, J.F. The impact of climate change on the world's marine ecosystems. *Science* **2010**, *328*, 1523–1528. [CrossRef] [PubMed]
46. Allison, E.H.; Bassett, H.R. Climate change in the oceans: Human impacts and responses. *Science* **2015**, *350*, 778–782. [CrossRef]
47. Zhang, Y.; Dutkiewicz, S.; Sunderland, E.M. Impacts of climate change on methylmercury formation and bioaccumulation in the 21st century ocean. *One Earth* **2021**, *4*, 279–288. [CrossRef]
48. Halpern, B.S.; Walbridge, S.; Selkoe, K.A.; Kappel, C.V.; Micheli, F.; D'Agrosa, C.; Bruno, J.F.; Casey, K.S.; Ebert, C.; Fox, H.E.; et al. A Global Map of Human Impact on Marine Ecosystems. *Science* **2008**, *319*, 948–952. [CrossRef]
49. Haines-Young, R.; Potschin, M. The links between biodiversity, ecosystem services and human well-being. In *Ecosystem Ecology: A New Synthesis*; Raffaelli, D., Frid, C., Eds.; BES Ecological Reviews Series; Cambridge University Press: Cambridge, UK, 2010.
50. Filipkowska, A.; Lubecki, L.; Szymczak-Żyła, M.; Ciesielski, T.M.; Jenssen, B.M.; Ardelan, M.V.; Mazur-Marzec, H.; Breedveld, G.D.; Oen, A.M.P.; Zamojska, A.; et al. Anthropogenic impact on marine ecosystem health: A comparative multi-proxy investigation of recent sediments in coastal waters. *Mar. Pollut. Bull.* **2018**, *133*, 328–335. [CrossRef]
51. Maes, J.; Teller, A.; Erhard, M.; Grizzetti, B.; Barredo, J.I.; Paracchini, M.L.; Condé, S.; Somma, F.; Orgiazzi, A.; Jones, A.; et al. *Mapping and Assessment of Ecosystems and Their Services: An Analytical Framework for Ecosystem Condition*; Publications Office of the European Union: Luxembourg, 2018.
52. Schernewski, G.; Inácio, M.; Nazemtseva, Y. Ecosystem service assessment in coastal and marine planning and management: A Baltic case study. *Front. Environ. Sci.* **2018**, *6*, 1–14. [CrossRef]
53. Townsend, M.; Davies, K.; Hanley, N.; Hewitt, J.E.; Lundquist, C.J.; Lohrer, A.M. The Challenge of Implementing the Marine Ecosystem Service Concept. *Front. Mar. Sci.* **2018**, *5*, 1–13. [CrossRef]
54. Manea, E.; Carlo, D.; Depellegrin, D.; Agardy, T.; Gissi, E. Multidimensional assessment of supporting ecosystem services for marine spatial planning of the Adriatic Sea. *Ecol. Indic.* **2019**, *101*, 821–837. [CrossRef]
55. Harrison, P.A.; Dunford, R.; Barton, D.N.; Kelemen, E.; Martín-López, B.; Norton, L.; Termansen, M.; Saarikoski, H.; Hendriks, K.; Gómez-Baggethun, E.; et al. Selecting methods for ecosystem service assessment: A decision tree approach. *Ecosyst. Serv.* **2018**, *29*, 481–498. [CrossRef]
56. Vihervaara, P.; Mononen, L.; Nedkov, S.; Viinikka, A. Biophysical Mapping and Assessment Methods for Ecosystem Services. Deliverable D3: 2018. Available online: http://www.esmeralda-project.eu/getatt.php?filename=ESMERALDA%20D3.3_14966.pdf (accessed on 28 July 2021).
57. Harris, P.T.; Baker, E.K. Why Map Benthic Habitats? In *Seafloor Geomorphology as Benthic Habita*; Peter, T., Harris, E., Baker, K., Eds.; Elsevier: Amsterdam, The Netherlands, 2012; pp. 3–22. ISBN 9780123851406.
58. Harris, P.T.; Baker, E.K. GeoHab Atlas of seafloor geomorphic features and benthic habitats–synthesis and lessons learned. In *Seafloor Geomorphology as Benthic Habitat*, 2nd ed.; Peter, T., Harris, E., Baker, K., Eds.; Elsevier: Amsterdam, The Netherlands, 2020; pp. 969–990. ISBN 9780128149607.
59. Lecours, V. On the Use of Maps and Models in Conservation and Resource Management (Warning: Results May Vary). *Front. Mar. Sci.* **2017**, *4*, 288. [CrossRef]
60. Buonocore, E.; Picone, F.; Donnarumma, L.; Russo, G.F.; Franzese, P.P. Modeling matter and energy flows in marine ecosystems using emergy and eco-exergy methods to account for natural capital value. *Ecol. Model.* **2019**, *392*, 137–146. [CrossRef]
61. Veettil, B.K.; Ward, R.D.; Lima, M.D.A.C.; Stankovic, M.; Hoai, P.N.; Quang, N.X. Opportunities for seagrass research derived from remote sensing: A review of current methods. *Ecol. Indic.* **2020**, *117*, 106560. [CrossRef]
62. Appolloni, L.; Buonocore, E.; Russo, G.F.; Franzese, P.P. The use of remote sensing for monitoring posidonia oceanica and marine protected areas: A systemic review. *Ecol. Quest.* **2020**, *31*, 7–17. [CrossRef]
63. Barbosa, C.A.; Atkinson, P.M.; Dearing, J.A. Remote sensing of ecosystem services: A systematic review. *Ecol. Indic.* **2015**, *52*, 430–443, ISSN 1470-160X. [CrossRef]

64. Mattei, F.; Buonocore, E.; Franzese, P.P.; Scardi, M. Global assessment of marine phytoplankton primary production: Integrating machine learning and environmental accounting models. *Ecol. Model.* **2021**, *451*, 109578. [CrossRef]
65. Obst, C.; Hein, L.; Edens, B. National accounting and the valuation of ecosystem assets and their services. *Environ. Resour. Econ.* **2015**, *64*, 1–23. [CrossRef]
66. Walz, A.; Schmidt, K.; Ruiz-Frau, A.; Dyankov, A.; Joyce, D.; Liski, A.H.; Marbà, N. Sociocultural valuation of ecosystem services for operational ecosystem management: Mapping applications by decision contexts in Europe. *Reg Environ. Chang.* **2019**, *19*, 2245–2259. [CrossRef]
67. Queiroz, L.S.; Rossi, S.; Calvet-Mir, L.; Ruiz-Mallén, I.; García-Betorz, S.; Salvà-Prat, J.; de Andrade Meireles, A.J. Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes. *Ecosyst. Serv.* **2017**, *26*, 137–145. [CrossRef]
68. Chan, K.M.A.; Balvanera, P.; Benessaiah, K.; Chapman, M.; Díaz, S.; Gómez-Baggethun, E.; Gould, R.; Hannahs, N.; Jax, K.; Klain, S.; et al. Opinion: Why protect nature? Rethinking values and the environment. *Proc. Natl. Acad. Sci. USA* **2016**, *113*, 1462–1465. [CrossRef] [PubMed]
69. Scully-Engelmeyer, K.M.; Granek, E.F.; Nielsen-Pincus, M.; Brown, G. Participatory GIS mapping highlights indirect use and existence values of coastal resources and marine conservation areas. *Ecosyst. Serv.* **2021**, *50*, 101301. [CrossRef]
70. Chen, W.; Van Assche, K.A.M.; Hynes, S.; Bekkby, T.; Christie, H.C.; Gundersen, H. Ecosystem accounting's potential to support coastal and marine governance. *Mar. Policy* **2020**, *112*, 103758. [CrossRef]
71. Friedrich, L.A.; Weatherdon, L.V.; King, S.; Vause, J.; Brown, C. Experimental Seagrass Ecosystem Accounts: Protocols for Pilot Accounts, UNEP-WCMC Technical Report (Draft Version) on Behalf of the European Environment Agency as Part of the Knowledge Innovation Project on Integrated System for Natural Capital and Ecosystem Services Accounting (KIP INCA). 2019. Available online: https://ec.europa.eu/environment/nature/capital_accounting/pdf/Seagrass%20Marine%20Accounts.pdf (accessed on 28 July 2021).
72. Costanza, R.; D'Arge, R.; De Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O'Neill, R.V.; Paruelo, J.; et al. The value of the world's ecosystem services and natural capital. *Nature* **1997**, *387*, 253–260. [CrossRef]
73. de Groot, R.; Brander, L.; van der Ploeg, S.; Costanza, R.; Bernard, F.; Braat, L.; Christie, M.; Crossman, N.; Ghermandi, A.; Hein, L.; et al. Global Estimates of the Value of Ecosystems and Their Services in Monetary Units. *Ecosyst. Serv.* **2012**, *1*, 50–61. [CrossRef]
74. Costanza, R.; De Groot, R.; Sutton, P.; Van Der Ploeg, S.; Anderson, S.J.; Kubiszewski, I.; Farber, S.; Turner, R.K. Changes in the global value of ecosystem services. *Glob. Environ. Chang.* **2014**, *26*, 152–158. [CrossRef]
75. Pendleton, L.H.; Thebaud, O.; Mongruel, R.C.; Levrel, H. Has the value of global marine and coastal ecosystem services changed? *Mar. Policy* **2016**, *64*, 156–158. [CrossRef]
76. Depellegrin, D.; Menegon, S.; Gusatu, L.; Roy, S.; Misiune, I. Assessing marine ecosystem services richness and exposure to anthropogenic threats in small sea areas: A case study for the Lithuanian sea space. *Ecol. Indic.* **2020**, *108*, 105730. [CrossRef]
77. Outeiro, L.; Rodrigues, J.G.; Damásio, L.; Lopes, P. Is it just about the money? A spatial-economic approach to assess ecosystem service tradeoffs in a marine protected area in Brazil. *Ecosyst. Serv.* **2019**, *38*, 100959. [CrossRef]
78. Hauck, J.; Görg, C.; Varjopuro, R.; Ratamäki, O.; Maes, J.; Wittmer, H.; Jax, K. "Maps have an air of authority": Potential benefits and challenges of ecosystem service maps at different levels of decision making. *Ecosyst. Serv.* **2013**, *4*, 25–32. [CrossRef]
79. Burkhard, B.; Maes, J. *Mapping Ecosystem Services*; Pensoft Publishers Ltd.: Sofia, Bulgaria, 2017.
80. Wolff, S.; Schulp, N.; Verburg, P. Mapping ecosystem services demand: A review of current research and future perspectives. *Ecol. Indic.* **2015**, *55*, 159–171. [CrossRef]
81. Honey-Rosés, J.; Baylis, K.; Ramírez, M.I. A Spatially Explicit Estimate of Avoided Forest Loss. *Conserv. Biol.* **2011**, *25*, 1032–1043. [CrossRef]
82. Orenstein, D.E.; Groner, E. In the eye of the stakeholder: Changes in perceptions of ecosystem services across an international border. *Ecosyst. Serv.* **2014**, *8*, 185–196. [CrossRef]
83. Pauly, D. Tales of a Small, but crucial fish: Review of The Most Important Fish by H. Bruce Franklin. *Science* **2007**, *318*, 750–751. [CrossRef]
84. Thiault, L.; Collin, A.; Chlous, F.; Gelcich, S.; Claudet, J. Combining participatory and socioeconomic approaches to map fishing effort in small-scale fisheries. *PLoS ONE* **2017**, *12*, e0176862. [CrossRef]
85. Caro, C.; Pinto, R.; Marques, J.C. Use and usefulness of open source spatial databases for the assessment and management of European coastal and marine ecosystem services. *Ecol. Indic.* **2018**, *95*, 41–52. [CrossRef]
86. Tempera, F.; Liquete, C.; Cardoso, A.C. *Spatial Distribution of Marine Ecosystem Service Capacity in the European Seas*; Publications Office of the European Union: Luxembourg, 2016.
87. Tyberghein, L.; Verbruggen, H.; Pauly, K.; Troupin, C.; Mineur, F.; De Clerck, O. Bio-ORACLE: A global environmental dataset for marine species distribution modelling. *Glob. Ecol. Biogeogr.* **2012**, *21*, 272–281. [CrossRef]
88. Berg, T.; Fürhaupter, K.; Teixeira, H.; Uusitalo, L.; Zampoukas, N. The Marine Strategy Framework Directive and the ecosystem-based approach—Pitfalls and solutions. *Mar. Pollut. Bull.* **2015**, *96*, 18–28. [CrossRef] [PubMed]
89. EU. *The EU Biodiversity Strategy to 2020*; Publications Office of the European Union: Luxembourg, 2011; ISBN 978-92-79-20762-4. [CrossRef]

90. Ruckelshaus, M.; McKenzie, E.; Tallis, H.; Guerry, A.; Daily, G.; Kareiva, P.; Polasky, S.; Ricketts, T.; Bhagabati, N.; Wood, S.A.; et al. Notes from the field: Lessons learned from using ecosystem service approaches to inform real-world decisions. *Ecol. Econ.* **2015**, *115*, 11–21. [CrossRef]
91. Guerry, A.D.; Polasky, S.; Lubchenco, J.; Chaplin-Kramer, R.; Daily, G.C.; Griffin, R.; Ruckelshaus, M.; Bateman, I.J.; Duraiappah, A.; Elmqvist, T.; et al. Natural capital and ecosystem services informing decisions: From promise to practice. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, 7348–7355. [CrossRef]